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THE ADULT ANATOMY AND HISTOLOGY OF THE ANAL GLANDS OF THE RICHARDSON GROUND-SQUIRREL, CITELLUS RICHARDSONII, SABINE

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NINE PLATES (TWENTY FIGURES)

The specialized integumentary glands of mammals have been investigated in varying degrees of completeness by a number of workers in the past. These glands, which are believed to be modified sudoriferous and sebaceous glands, may occur in many places upon the exterior of the body, but perhaps the most important class of them (leaving out of consideration the mammary glands) comprises the glands which are developed in the region of the anus. In this region it is common, if not invariable, to find the sebaceous and sweat glands enlarged, and producing a secretion more or less odoriferous. Frequently these glands are scattered diffusely upon the wall of the anal canal or upon the skin of the perinaeum; in many mammals, however, particularly among the orders Carnivora and Rodentia, the glands may be aggregated into masses of considerable size which are provided with muscular investments, storage vesicles, and ducts opening to the surface on papillae. This degree of morphological complexity is associated with a corresponding elaboration of the physiological functioning of the glands, the secretion being copious in amount and containing special products, usually of a highly odoriferous character.

In 1874 Chatin published an extensive monograph on the odoriferous glands of mammals, dealing with the anal and perinaeal glands of the orders Carnivora and Rodentia. In

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the latter order he described the glands of Castor, Mus decumanus, Dasyprocta, Atherura, Lepus cuniculus, and Arctomys marmotta. The Carnivora, however, have received most attention in respect of these glands. Mivart ('82) dealt with the external characters of the glands of Genetta tigrina and Pocock ('15) described the grosser morphological features of the glands of Genetta pardina and Civettictus civetta. The histology of the anal canal and its associated glands in the dog has been investigated by Hebrant ('99), Zimmerman ('04), and Mladenowitsch ('07). Apart from this work upon the dog, most of the papers just mentioned have related rather more to the grosser anatomy of the glands than to minute histological structure, their purpose having been mainly taxonomic. While Chatin presents the results of some histological study upon the glands of certain of the mammals he describes, the only work the present writer has been able to discover treating exhaustively of the microscopic anatomy of a mammalian anal gland is furnished by the papers on the odoriferous glands of the skunk, Mephitis mephitica, first by T. B. Aldrich, who describes but does not figure the histology of the glands in a paper upon the chemical nature of the secretion ('96), and by Blackman ('11).

In the case of the Rodentia, comparatively little work seems to have been done, at any rate with which I am acquainted. The perinaeal sac of the guinea-pig was described fully by Grosz ('04). The only work I know of upon the squirrels or closely related rodents is the brief account of the glands of Arctomys marmotta (fam. Sciuridae) by Chatin in his paper of half a century ago. Chatin figures three tubercles opening into the wall of a pouch, at the bottom of which the anus is situated, the arrangement being very similar to the structures found in Citellus richardsonii. He does not, however, refer in any detail to the histology of the glands of Arctomys, although he has dealt with this aspect at somewhat greater length in the case of several of the other mammals he describes. He refers, in the case of several of the Carnivores, to the existence of two superposed muscular

zones ensheathing the glandular masses, the direction of whose fibers is mutually perpendicular, and to the development of muscular septa penetrating between the portions of the secretory tissue. He discusses the origin of these muscles, referring to the theories of the earlier anatomists that they might be 'muscles ambiants,' or derived from abdominal muscles, but he states that he arrives at no conclusions on his own part. Blackman, in investigating the musculature of the anal glands of the skunk, refers to the statements made elsewhere that there is a connection between the muscle sheath and the tail which assists in the mechanical discharge of the fluid when the tail is raised, but apparently the material at his disposal did not permit of the fuller investigation of this point. Blackman describes, in the skunk, bands and sheets of unstriated muscle in the corium of the gland vesicle which he regards as a derivative of the muscularis mucosae of the rectum, but puts forward no view as to the derivation of the striated constrictor sheath round the vesicle. I refer to the muscles at this stage, because special attention has been paid to them in the present paper, and because they are features of morphological importance in a study of these glands.

For the purposes of this paper the author has been favored by an abundance of material which made possible observations upon the mechanical functioning of the papillae in the living condition, and also the cutting of complete series of sections across the gland masses at various angles. The ground-squirrel Citellus richardsonii[1] is the common burrowing mammal of the prairies of North America and was readily available on the campus of the University of Saskatchewan, where a portion of this work was done. The animal can be obtained by trapping, and, if not too seriously injured in the trap, will recover in captivity. It requires but little observation to note the conspicuous papillae of the anal glands, which are protruded when the animal is alarmed. The

[1] Commonly known as the gopher, though the name prairie gopher is more correct, since the true or pocket gopher, Geomys bursarius, belongs to a different family of rodents, the Geomyidae.

author's interest in this subject, indeed, was aroused in this way.

In order to investigate the structure of these organs, dissections were performed to elucidate their grosser features, and then the glands, together with the anal canal and a portion of the perinaeum, were removed and fixed in Bouin or Zenker. It was found also that the glands from specimens preserved in formalin gave quite good results from the histological point of view. Four sets of glands were embedded and cut into serial sections at different planes. In all some 900 sections were studied, and the relationships of the different tissues were elucidated by tracing them out in the series. By this means a complexity of structure was revealed greater than that indicated in previous accounts of mammalian anal glands, and it has been possible to establish definitely the relationships of the muscle sheaths (for this animal at all events).

THE GROSS ANATOMY OF THE ANAL GLANDS

Chatin's account appears to reveal two distinct tendencies along which the evolution of the aggregated gland masses in mammals has proceeded. On one hand, the aggregation has taken place upon the perinaeum, such perinaeal glands, some distance away from the anus, producing a powerful but not foetid odor; and, on the other hand, the concentration has led to complex glands upon the wall of the anal canal, or anal glands, which are usually hidden when the anus is contracted and whose secretion is often highly foetid. In many mammals, notably the civets and the beaver, both kinds of complex glands occur together. A further class of glands is worthy of mention, namely, the preputial glands found in the rat and other mammals, which are to be assigned to a different category, since they appear to be derived from accessory reproductive glands.

When large anal glands are developed, their number is usually two (right and left of the anal axis). In Arctomys the number is three, one of which is median, and this obtains

for Citellus, too, though sufficient data are not to hand to say whether the possession of three glands is characteristic of the Sciuridae.

The three gland masses in Citellus are enclosed in a common investment of areolar tissue and striated muscle, and they open in the retracted state by three large apertures upon the anal wall (fig. 3). Chatin, in the case of Arctomys, refers to the glands as opening into a pouch, at the bottom of which the anus is situated. The designation of a special pouch appears to be arbitrary in the case of Citellus, or at any rate if such a pouch can be said to be marked off, it is merely a portion of the anal canal. The three glands open upon the anal wall or, if preferred, the region of transition between anal membrane and skin. As will be shown later, a study of the musculature of the glands suggests that they are embedded within the sphincter externus of the anus, and there appears to be little reason for designating this portion of the anal canal by a special name.

Normally, the openings of the glands are concealed within the anal orifice, but the animal has the power, by voluntary action, of everting the channels which then protrude from the relaxed anus as three stout diverging papillae of a reddish[2] color (figs. 1, 2). As far as my observations upon the living animals show, the papillae are protruded when the animal is irritated or alarmed. When one approaches the trap, the captured animal will deliberately display its anal region, protruding the papillae spasmodically in a manner which suggests that they may have a sematic function. The animal turns upon its back, uttering sharp cries, and protruding the papillae, which give it a somewhat startling appearance and might conceivably cause a dog to hesitate to attack it. No secretion is apparently discharged under such circumstances, at any rate not forcibly, and, since the secretion is practically odorless and non-acrid, it is not easy to understand why the animal should make a display of the papillae when attacked.

[2] The reddish color of the papillae is merely due to the abundance of vascular dermal papillae of the corium of their integumentary lining, not to pigmentation.

The warning function is of course merely a suggestion. That the glands play some part in the defense of the animal is suggested by the fact that the animal will frequently endeavor to reach the hand with its anal region, and the discharge of secretion can be promoted by touching the protruded papillae with the end of a stick or other blunt object. The secretion is a thick cloudy fluid, of a cream or pale brown color, containing in suspension the keratinized remains of desquamated epithelial cells and products of nuclear degeneration.

If a freshly killed animal be subjected to pressure in the abdominal region, the anal wall is caused to stretch and the openings of the introverted channels can be seen within the anal orifice (fig. 3). The openings are three in number, appearing as radially disposed slits, with somewhat tumid lips, as figured by Chatin for Arctomys. They belong to the ventral half of the anal wall; one of them is median and ventral, and the other two right and left, situated nearly half-way up the anal wall. The channels of the glands, when everted as papillae, are thus situated on the side of the anal wall toward the genital aperture. If an incision be made through the skin so as to surround the anus and the perinaeum up to the urogenital aperture (in the male the testes are retracted except at the breeding season, so that the operation is simplified by the absence of the scrotum), and the portion of the skin thus separated from the rest is raised and examined from the inside, a bulbous mass invested by connective tissue and fat can be seen in the angle between the lower portion of the rectum and the skin of the perinaeum. This mass is about the size of a large pea, and, when the loose connective tissue is dissected away, is seen to consist of three subdivisions, closely apposed and united by a firmer sheath of connective tissue and muscle (fig. 4). Each of these three subdivisions is an independent mass of glandular alveoli, comprising, as will be shown presently, two distinct kinds of glandular elements, surrounded by its own investing layers and provided with its own evertible channel. One of the glandular masses is median and ventral and the other two are closely apposed

to it on each side. The three glands are enclosed by a common sheath of loose areolar tissue, which is continuous with the panniculus adiposus of the adjacent skin. It was this layer which was mentioned above as requiring to be dissected away to reveal the triple layer of the whole glandular mass. The glands are seen now to be surrounded by a sheath of striated muscle. A cross-section shows that this sheath is prolonged inward between them in the form of two septa (fig. 7, *9*). Each gland consists of, *a*) an outer mass of secreting lobules (*2*) lying immediately below the constrictor sheath of muscle, and loosely surrounding *b*) a considerably larger mass of lobules of a different kind of glandular tissue (*10*), opening into the base of the evertible channel. By the contraction of the muscle sheath and its septa, the masses are compressed and the channels are everted as papillae.

THE INVESTING COATS OF THE GLANDS

The three glands are invested beneath the skin by a mass of loose connective tissue, already referred to as a portion of the panniculus adiposus pushed inward by the development of the glands. This appears vesicular in sections prepared in the usual way, the fat having been dissolved out. Within the panniculus adiposus the glands are surrounded by a firm investing sheath of striated muscle; this muscle layer consists of numerous flattened fasciculi whose arrangement reveals that the layer is double. The outermost portion constitutes a common sheath for the three glands, which themselves are surrounded individually by coats of striated muscle (fig. 7, *6, 7*). The outer coat is common to the three glands and its fasciculi run at varying degrees of inclination around the whole mass, forming the main constrictor muscle. This sheath is complete everywhere around the fundus portion of the glands and is continued toward the surface of the skin on the side away from the anal canal. Between the glandular masses and the anal canal it is very thick (figs. 8, 12), becoming continuous with the sphincter ani externus. If the panniculus adiposus is dissected away from the angle

between glands and rectum, and the glands are then stretched away from the rectum by their funduses, the junction between the common constrictor muscle and the sphincter ani externus can be seen as three thickened areas, one region of the thickening being opposite each fundus (fig. 5). The striated muscle sheath is lacking from the extreme corner between the anal canal and the secretion channels formed by the introverted papillae. The common constrictor is covered on its outer and inner faces by a layer of areolar tissue. This constitutes the epimysium of the muscle and merges on the outer side with the panniculus adiposus. On the inner side it merges with the epimysium of the imperfectly developed individual constrictor sheaths, in places passing between their scattered fasciculi to become continuous with the framework of the areolar tissue which supports the glandular alveoli (fig. 6).

The muscle sheaths of the individual glands consist, like the common sheath, of striated muscle grouped into fasciculi running at various angles to one another. These three inner sheaths, however, are comparatively poorly developed and in many places incomplete. The demarcation between the inner sheaths and the common outer sheath is often represented in section by a distinct space containing connective tissue formed by the adjacent epimysia. In other places the fasciculi of both sheaths approximate so closely that the distinction between the two sheaths is lost. If one of the fasciculi in the inner sheath of either lateral gland be compared with the immediately superposed fasciculus of the common sheath, it is generally to be observed that the directions in which the two fasciculi run, as indicated by the shape of the cut ends of the muscle fibers, are inclined at an angle of about 90°. In the case of the median gland the fibers of the inner sheath and the common sheath run nearly parallel (fig. 7). Since the inner sheaths circle the glands individually, the median gland is separated from the outer glands by a septum of muscular tissue formed by the apposition of the inner sheath of the median gland with the inner sheaths of the lateral glands (fig. 7, *9*). The double origin of this septum is to be seen in

section where the septum meets the periphery of the gland mass. The outer glands are roughly of a hemispherical shape (fig. 7), closely apposed to the median gland which is of a short subcylindrical form. Thus the separating muscular septa are roughly circular and flat. Round the periphery of the circular septum the separation of the two inner sheaths forming the double septum from each other and from the common outer sheath is marked by a triradiate mass of areolar tissue derived from the meeting of the three epimysia (fig. 7, *5*). In the septum, which itself possesses little connective tissue, the fasciculi derived from both sheaths run parallel, and the double character of the septum is often lost. The dividing strip of areolar tissue, representing the epimysia of the two coats forming the septum, breaks up into diverging fibers which spread as epimysial partitions among the individual fibers irrespective of which sheath they belong to, so that in the central zone of the septum complete merging of the two sheaths may be considered to have taken place. In one of the sectioned specimens, however, the division of the septum was apparent across its whole extent.

The fact, previously pointed out, that the striated muscle associated with the gland masses is continuous with the sphincter ani externus, shows clearly its derivation. The glands are to be regarded as invaginations of the anal wall carrying the sphincter before them. From the sphincter became developed their investments of voluntary constrictor muscle. With reference to the areolar tissue forming the epi-, peri-, and endomysial sheaths of the fasciculi and muscle fibers, it may be pointed out that this and the areolar tissue forming the framework supporting the glandular alveoli are both identical in structure and continuous with the corium of the perinaeum, and therefore presumably derivatives of it.

Giant muscle fibers were found occasionally in the constrictor coats, usually in the angle between the glands and the rectum.

THE ACTION OF THE VOLUNTARY MUSCLES AND THE PROTRUSION OF THE PAPILLAE

The eversion of the channels and the discharge of stored secretion are effected by the contraction of the striated constrictor coats. Relaxation of the anal orifice occurs to allow the papillae to protrude, which implies that the end of the sphincter proper is relaxed while what is equivalent to a portion of it, namely, the muscular coats of the glands, is contracted simultaneously. The effect of the pressure produced by the muscular contraction upon the plastic alveolar mass within is to bring about evagination of the normally introverted papillae. Since the triple gland mass is of an oval shape, the development of muscular septa separating the glands is a provision to insure the equalization of pressure upon the glandular tissue; otherwise the contraction of a purely peripheral muscle sheath would tend to press the mass into a spherical shape, losing some of the contractile effort in so doing, before the papillae were everted. Each of the glands is compressed by its individual sheath, and the three glands are compressed by the common outer sheath. Since the glands are disposed side by side, the combined effect is to produce divarication of the protruded papillae (fig. 2). The papillae themselves are devoid of intrinsic muscles, and they have no power of movement, as far as could be observed, other than that of protrusion and withdrawal. In this respect they differ from the skunk, where the papilla can be directed in position so as to discharge the fluid in a desired direction.

The gopher makes a deliberate display of the papillae, and it is to be observed that their protrusion is of a spasmodic nature. They are everted sharply and suddenly, relaxation of the constrictor muscles occurring almost immediately. The papillae are then introverted more slowly and disappear within the anus, the orifice of which closes over them. The body of the protruded papilla is filled by the glandular tissue, whose displacement by the constrictor creates the papilla.

THE RETRACTION OF THE PAPILLAE

It is evident that introversion of the papillae must be effected by definite retractor muscles, for mere relaxation of the constrictor coat would not be adequate to bring about their withdrawal. The fact that the papillae were withdrawn more slowly than they are protruded, moreover, seemed to indicate that the retraction was effected by unstriated fibers. Chatin, while referring to the occurrence of 'muscle lisse' in the anal glands, does not discuss the question of the retraction of the papillae when the latter are introvertible, as in the marmot, nor does Blackman, in reference to the skunk. Indeed, the possibility or even the need of muscle acting antagonistically to the constrictor-protractor coat might readily be overlooked. On finding that the voluntary constrictor muscles of the glands were derived from the external sphincter, I thought it not unlikely that the internal (involuntary) sphincter ani might furnish the retractor muscles of the papillae. Search was therefore made through the series of sections to discover the retractor muscles and establish their relationships. As a result of this, it is possible to affirm that the retraction of the papillae is effected by unstriated fibers derived not from the sphincter internus as I had expected, but from the longitudinal muscle coat of the rectum, which, in Citellus, extends down between the sphincter externus and the sphincter internus. (In most mammals the longitudinal muscle layer of the large intestine does not extend into the wall of the anal canal, though it would be interesting to examine those that possessed protrusible anal papillae, to see if a similar arrangement did not obtain.) In the skunk, Blackman refers to bands and sheets of unstriated muscle in the pars reticularis of the corium of the vesicle, which are derivatives of the muscularis mucosae. He does not, however, refer to the muscle layer proper of the rectum (which is distinct from the muscularis mucosae), nor to the relationship of the strands he specifies to the mechanism of retraction of the papillae, if any relationship exists.

The fibers of the longitudinal coat of the rectum (fig. 10, *2*) are collected between the two sphincters into a number of fasciculi of different sizes which are inserted at their lower ends into some bundles of white fibers which serve as the retractor ligaments of the glands. These retractor ligaments are three in number, one for each gland, and the central one supplying the median gland is the largest and the most definite in structure. This median retractor ligament is in the form of a prominent band of white parallel fibers (fig. 10, *3*) running in the median plane from a group of the fasciculi of unstriated muscle lying about the midventral line of the wall of the anal canal. In this group (*2*) the median fasciculus is distinctly larger than the others which lie to right and left of it, all attached to the frayed end of the median ligament.

It will be remembered from the preceding account that the striated constrictor coat is exceptionally thick in the angle between glands and anal canal; that is, where the muscular coat takes origin from the sphincter ani externus. Across this thickened region the median ligament runs in the median plane, sharply interrupting the striated fibers, which run at right angles to it. Their sarcolemmas are inserted upon the ligament, which runs back so as to bisect the sphincter externus for some distance, till it joins the plain muscle of the longitudinal or middle coat. In other words, the sphincter externus and the constrictor sheath of the glands are bisected in the midplane by the ligament, their striated fibers being actually inserted upon it. The median ligament extends from the involuntary fasciculi through the lower portion of the sphincter externus and then sends an offshoot toward the angle between the median gland and the anal canal. The main portion of it continues round the fundus of the median gland (fig. 11, *lig.*) and merges into the areolar reticulum which invests the alveoli of the gland. This ligament thus has somewhat the same relation to the gland that the hand would have to an orange that was held in the angle between the thumb and the rest of the hand, the thumb and fingers being outstretched in one plane. Since the ligament merges into

the reticulum of the gland, the tension it exerts is distributed to the whole glandular tissue and to the base of the channel which becomes the summit of the everted papilla. Hence when the retractor muscles contract the papilla is introverted.

In the case of the two lateral glands, the retractor ligaments are not so highly developed, being in the form of diffuse bundles of white fibrous tissue (not organized into a plane sheet like the median ligament) running, in the retracted glands, in a roughly curved direction on each side of the axis of the gland mass, and at a lower level than the median retractor ligament (fig. 12, *7, 7*). They are continuous proximally with fasciculi of plain muscle situated more laterally in the wall of the lower portion of the rectum which, like the retractor muscles of the median gland, belong to the longitudinal coat. Distally, the lateral retractor ligaments spread out laterally to connect diffusely with the supporting reticulum of the lateral glands. The lateral retractors extend nearer to the mouths of the inverted channels than does the median ligament, so that in the photograph (fig. 12) only the lateral retractor ligaments are seen at the particular level of the section. In this region also, which is close to the opening of the median gland upon the anal wall, the constrictor coat is absent except at the sides where the thick masses at the junctions between sphincter and constrictor are seen, the striated muscle not extending into the extreme angle between glands and anal canal. The lateral retractor ligaments interrupt the constrictor coats of the lateral glands, whose fibers are inserted upon them just as the fibers were inserted upon the median retractor at a level nearer the fundus of the median gland, though in the case of the lateral ligaments the interruption to the muscle substance is not of so rigid a nature.

The insertion of the striated fibers which serve for the protrusion of the papillae upon the ligaments which serve for their retraction seems anomalous at first sight. It must, however, be borne in mind that the median ligament runs at right angles to the striated fibers whose opposed contraction produces no movement in it, while the involuntary fibers which

pull the ligament are collinear with it. The ligament constitutes merely an interruption in the contrictor muscle of no mechanical significance. In the case of the lateral ligaments, some striated muscle is inserted upon their lateral sides. Very little muscle is inserted upon the medial sides of the lateral ligaments; on this side each ligament merges into a mass of areolar tissue in the top portion of the angle between median channel and the sphincter ani internus (the sphincter externus, as explained, being absent from the extreme corner). This intervening tissue is equivalent to a supporting connection between the lateral ligaments against the contraction of the striated fibers which are inserted upon their lateral sides.

THE STRUCTURE OF THE INTROVERTED PAPILLAE

Each of the three glands discharges its secretion through an aperture at the extremity of the everted papilla. The latter is about 8 mm. in length and 3 mm. thick, cylindrical or slightly barrel-shaped. Ordinarily, the papilla is introverted, forming a capacious channel leading from the glandular mass to the anal wall (fig. 6). The term 'channel' is preferred to 'duct' for several reasons. Although the introverted papilla is equivalent to an invagination of the ectoderm (of the anal wall), such an involution cannot be compared to the type of invagination represented by the duct of a sweat or a sebaceous gland. In the first place, the introvert is not permanent, since it can be turned inside out; and in the glands just mentioned the invagination is a downgrowth of the rete mucosum, while in the case of the channels of the anal glands the whole skin is bodily involved, mesoderm as well as ectoderm. The true ducts, moreover, as distinguished by their histological structure and their relationship to the alveoli, are not extrovertible, and they represent true invaginations of the base of the channel, which itself is to be regarded as a pocket of the skin.

If the channel be examined in section (figs. 6, 9), it will be observed that its wall exhibits the structure of mammalian skin devoid of hairs and sweat glands. Adjacent to the lumen of the channel is a stratum corneum of exceptional thickness

which presents an irregularly laminated appearance, owing to the presence of many partly dissociated layers of the keratinized remains of the epithelial cells. It will be understood that when the channel is everted, the stratum corneum bordering the lumen of the channel in the retracted state becomes the outer layer of the protruding papilla. Hence the thickness of the lining of the channel, which would be unusual were the channel always in a state of involution, can be accounted for, since the papilla will need a well-developed protective surface. It is to be noted, however, that the stratum corneum of the channel is considerably thicker than in the adjacent anal wall or even than in the normal skin. This point, in my opinion, is worthy of note, for in the anal glands of the gopher we find a remarkably high production of keratin in the form of shed-off keratinized cells. This tendency is well illustrated when we proceed to study the parts of the gland immediately connected with the channel.

At the base of the channel the stratum corneum of the wall frays out in a very noticeable manner (fig. 9) and the dissociated laminae form an irregular spongy reticulum of highly keratinized material. Into this spongy mass open many ducts from a series of lobules (fig. 6, *13*) which constitute the bulk of the glandular mass. The number of these lobules is about forty for each gland, and each lobule contains seventy or eighty saccular recesses or alveoli densely filled with epithelial cells. The central portions of these alveoli form a vacuolated spongy reticulum (fig. 13) continuous with the reticulum at the base of the channel, and serving to lodge the more fluid secretion of another series of glandular elements outside the lobules just described. The channel often contains a considerable amount of the desquamated secretion mass (fig. 6, *3*) which, near the mouth, is often mixed with sand grains and other debris from the outside (*1*). It will be borne in mind that what is referred to as the mouth of the channel when the gland is retracted forms the circular base of the papilla when eversion occurs, and the base of the channel into which the ducts open comes to the top. Thus,

any matter lying in the channel will be discharged when eversion takes place, and the spongy reticulum at the base of the channel will be brought to the surface. The protrusion of the papillae is not accompanied by discharge of secretion on every occasion. Frequently they are protruded by way of display without any expulsion of secretion. Presumably additional muscular contraction may be necessary to discharge the secretion from the spongy mass after the papillae are protruded, or it may be that the secretory activity is variable, the fluid secretion not always being present in sufficient amount. Some observations showed that it merely required contact with a foreign object to arouse discharge; at other times the creamy fluid was to be found upon the fur of the animal in the anal region when unprovoked by any external irritation.

Underlying the stratum corneum of the channel wall is a stratum granulosum of two or three cells in thickness (fig. 9, *6*). In some places the eleidin granules are difficult to detect. They are mostly strongly developed where the stratum corneum is thickest. The stratum lucidum of the normal skin, as far as can be ascertained, is lacking from the epidermis of the papilla. In a few places a slight transparency could be detected in the lower layers of the stratum corneum, but this was indefinite both in extent and thickness and could not be definitely identified with a stratum lucidum. Within the rete mucosum numerous dermal papillae (fig. 6, *12*) are to be seen. They project into the epidermis obliquely, and in section they appear frequently as detached clumps of cells. They enter the lower layer of the rete mucosum by narrow necks and then expand. No tactile corpuscles could be found in them, though they are very vascular. Their great number connotes a large blood supply to the wall of the channel and hence high nutritive requirements, doubtless associated with the unusually heavy formation of stratum corneum. Indeed, the increase in the number of dermal papillae is very marked at the entrance to the channel, if the skin is followed in the section along the anal wall and into the channel (fig. 8). The pronounced thickening of the stratum corneum also begins in the same place.

At the lower end of the channel, concomitantly with the fraying out of the stratum corneum, the cells of the rete mucosum become enlarged (fig. 9) by both cytoplasmic and nuclear growth. Cell division in this region is not marked. There is thus produced at the base of the channel a region of swelling of the rete mucosum, whose cells are desquamated off and undergo immediate disintegration after keratinization without passing through the normal compact stage of a stratum corneum. This result may be due to mechanical breaking of the stratum at this region during eversion, but more likely it is a manifestation of the transition of the epidermis into the sacculated gland masses now to be described.

THE STRUCTURE OF THE GLAND MASSES

Reference has already been made to the existence of two distinct types of glandular tissue forming the mass between the base of the channel and the muscular investing coat. The first type of gland elements to be encountered on proceeding inward comprises a dense mass of lobules immediately surrounding the base of the channel and occupying the greater part of the whole gland. Their ducts are continuous with the rete mucosum of the channel wall. Active desquamation of epithelial cells takes place in their alveoli and ducts, the desquamated cells being filled with particles of fatty material and undergoing disintegration to form a reticular mass which becomes highly vacuolated and drawn into irregular strands. The vacuolation becomes more and more pronounced as the secretion mass passes on toward the base of the channel. Figure 15 is a high-power photograph of the alveoli of these glandular elements, to show how they are filled with epithelial cells, and it will be noticed at once that they resemble very closely sebaceous glands unassociated with hairs. Hairless sebaceous glands are well known; also sebaceous glands associated with a rudimentary follicle (Sappey). In one instance a reduced and imperfect hair follicle occurred buried in the glandular mass, affording definite proof of the relation of the lobules to sebaceous glands, and suggesting that they

belong to Sappey's second category. Chatin regards all the anal and perineal glands he examined as derived from sebaceous glands. B. Rosenstadt has shown that a part of the cell substance in sebaceous glands undergoes keratinization—a fact which is amply illustrated here. The desquamated epithelial cells are seen to be highly keratinized, especially as they pass progressively toward the mouths of the alveoli and down the ducts. It seems possible, therefore, that the anal glands in Citellus may function for the disposal of superfluous keratin in a manner comparable to the shedding of hairs and antlers in other mammals. The production and elimination of keratin must be relatively enormous in these glands, and it is to be noted that we find the same tendency illustrated in the very thick stratum corneum of the papillae, which can hardly be needed for mere protection. I have not sufficient information to make a comparison with other mammals possessing anal glands with regard to this suggestion of a keratin-eliminating function. I am unaware of the point's having been raised before.

We now pass on to study the second type of glandular elements present in the anal glands. These consist of lobules smaller in size and number than the first (fig. 6, *7*). They are compressed between the latter and the muscular capsule, being slightly separated from both by areolar connective tissue which may be condensed into dense strands in places. Each of these outer-lying lobules is of the compound racemose type terminating in saccular alveoli lined by columnar or cubical epithelium surrounded by a basement membrane (fig. 16). The nuclei of the cells are situated in the basal portion of the cell. The free extremities of the cells are often drawn out into pear- or club-shaped processes, and this appears to be a preliminary to the shedding of the cell into the lumen of the alveolus. The lumen is distinctly open, in sharp contrast to the first type of alveoli; within it are to be seen many of the lining cells set free. These shed cells undergo cytolytic and degenerative changes presently to be referred to, and often become agglutinated into masses occupying the

lumen. Although the bodily destruction of gland cells as a concomitant of secretion is considered to be rare, it is generally admitted in connection with the sebaceous glands. We have, indeed, already described it in connection with the first type of glandular elements. There is reason, therefore, to regard the second type of elements as sebaceous glands like the first, though, as will be seen from the photographs and figures, they differ markedly in possessing open lumina and in the character of the lining cells. The latter resemble very closely the secreting epithelium of a mammary gland, although the latter is not usually regarded as derived from sebaceous glands. If figure 16 is compared with the photograph of a section of the mammary gland given on page 287 of Schaeffer's Essentials of Histology, 11th edition, this resemblance will be very obvious. Some of the cells, moreover, exhibit a fraying out of their free ends, which Blackman states is known to occur in the mammary gland.

That the glands under description, however, are sebaceous glands, like the first type, seems to be proved conclusively by the discovery of a rudimentary hair follicle associated with one of them (just as happened in the case of the first type also). The epithelial cells are variable in different glands or in different alveoli in the same gland. Doubtless, the differences are to be assigned to different states of secretory activity, for these alveoli are the ones in which the more fluid portion of the secretion is formed. In most cases the cells are as described above, with broad loose extremities, but in some alveoli they were found to be very highly columnar, their halves toward the lumen being clear and homogeneous and abutting closely upon the reduced lumen so that no irregular spaces lay between the outer portions of the cells as happens when they assume the club-shape. No polymorph nuclei were encountered comparable to what Blackman found in the skunk; but of course the comparison with a different order of mammals is rather a distant one to make.[3]

[3] The frequent comparisons with the skunk made in this paper arise out of the fact that Blackman's paper is the only work known to me which deals in

In the skunk, again, no shedding of cells into the lumen is reported.

The assumption of the irregular shapes of the epithelial cells is to be regarded as a preliminary to shedding, for in such alveoli the lumen always contains a mass of shed cells, while other alveoli possessing a regular wall have a clear open lumen. The open or half-open character of the lumen, as compared to the first-type lumen, indicates that it contains a considerable amount of fluid derived from the epithelium.

The lobules of the second type possess ducts of considerable length, and fairly thin (fig. 7, *3*). There is a sharp transition in the epithelium at the junction between duct and alveolus. The wall of the duct is composed of several layers of compact stratified cells, taking no part in the secretory activity or in desquamation (fig. 16). The ducts often divide sharply into two to connect with adjacent lobules, and branch within the individual lobes to serve the alveoli. They run in the connective-tissue stroma between the alveoli and the strands separating the lobules of the first type from those of the second type, and then run between the lobules of the first type (figs. 15, 19), to open directly into the base of the channel (or the summit of the papilla), along with the ducts of the first type. The second-type ducts are very different in character from the first type. They are longer and narrower and have a definitely specialized wall, while the latter are little more than the mouths of the densely filled saccules. In their course through the mass of first-type lobules the second-type ducts are invested by sheaths of connective tissue (fig. 15). Occasionally these ducts are distended by dense agglutinated masses of material (fig. 14, *4*) probably derived from the secretion products of their alveoli, though the origin of these distension masses has not been ascertained.

The spongy reticular mass filling the mouths of the first-type alveoli and the base of the channel apparently serves as

detail with the histology of an anal gland. It should be understood, moreover, that Blackman derives the odoriferous glands of the skunk from sweat, not sebaceous glands, for reasons which will be apparent if his paper be consulted.

an absorbent matrix to hold the more fluid secretion of the second-type glandular elements. In Chatin's account of the glands he studied there is no mention of two types of glandular elements.

'EXTRA-CAPSULAR' GLANDS

In two out of the four sets of glands sectioned there was found a single small gland identical in histological character with a detached second-type lobule situated outside the common muscular sheath on the side of the gland mass away from the anal canal (fig. 8, *10*). The duct (*13*) was single and very long, filled with a vacuolated secretion mass as described for the second-type lobules (p. 20, fig. 14, *4*) and it opened upon the perinaeum close to the anal orifice, in one case into a hair follicle. Here again the relationship to sebaceous glands is well illustrated by what appears to be an abnormally situated second-type lobule (outside the muscle sheath instead of inside).

THE CHANGES WHICH OCCUR IN THE EPITHELIAL CELLS OF THE SECOND-TYPE ALVEOLI PREPARATORY AND SUBSEQUENT TO SHEDDING

As has already been explained, the cells lining the second-type alveoli exhibit in most places club-shaped enlargements of their free extremities. The nucleus of the cell is normally situated at the base of the cell next to the basement membrane, but when the enlargement begins the nucleus migrates outward into the enlarged extremity. Sometimes (fig. 17) the enlargement of the cell is general. The interpretation of this is that the cell has room to enlarge sideways through a contiguous cell having moved away. During enlargement the cytoplasm becomes pale and the nucleus invariably moves away from the basement membrane. Cytolysis is taking place in the cell, and it can be seen in *A* how the nucleus is partly filled with fluid, the result of chromatolysis, and how the remaining chromatin has broken into two masses. The fluid nature of the cell is evinced by its globular shape. The cell has already moved away from the basement membrane, its

place being taken by the encroachment of the two adjacent cells, which by lateral enlargement have met beneath the cell that is being shed. When the cells are finally shed, the nucleus often becomes very small and opaque. The nuclear remains of the corpuscle often take on a crescentic shape (*C, D, E*), at one end of the original nuclear cavity, the remainder being occupied by fluid. The nuclear remains are later protruded from the cell whole (*D*) or in fragments (*F*). In *F* it is to be seen that the cytoplasm of the shed corpuscle has become filled with large vacuoles of fluid.

Frequently encystment of the desquamated cells occurs (*B*), the interior being filled almost entirely with fluid except for the nuclear remains, and it is to be observed that the nuclear membrane as well as the cell membrane is keratinized. These encysted corpuscles persist as independent bodies among the dense agglutinated mass derived from the other shed cells which may not have undergone an identical form of transformation. The former are to be found even in the reticulum of the first-type alveoli and in the channel (fig. 13, *3*). The encysted corpuscles may even undergo cell division. The process, however, appears to be degenerative, for the resulting nuclei are fragmented and their cytoplasm is unduly fluid (fig. 18). In figure 18 it is to be observed that an encysted corpuscle has become embedded in the epithelium of a first-type duct. The nuclei of the 'secondary' corpuscles that do not undergo encystment suffer extensive fragmentation, resulting in a cloud of opaque particles that diffuse into the keratinized reticulum of the first-type ducts.

THE SCATTERED ANAL GLANDS

Opening into the anal wall independently of the three large capsulated glands are groups of small mucous glands of the tubuloracemose type. They are lined both in the alveoli and the ducts by a cubical secretory epithelium resting on a basement membrane. The nucleus lies in the basal portion of the cells next the basement membrane. The cytoplasm is faintly granular. No desquamation occurs in these glands. They

appear to be mucous glands, and their presence side by side with the large glands upon the anal wall is useful to show that the latter are definitely not derived from mucous glands, from which they differ most markedly in possessing the characters described in this paper.

SUMMARY

In Citellus richardsonii three large gland masses, one median and ventral, two lateral, open upon the anal wall by evertible channels representing invaginations of the epidermis, the stratum corneum of which is greatly thickened. The channels are normally introverted, but when turned out they appear as three conspicuous papillae. The gland masses are surrounded by a sheath of striated muscle prolonged inward into septa between the glands and derived from the sphincter ani externus. The retraction of the papillae is effected by unstriated muscle derived from the longitudinal muscle coat of the large intestine which is prolonged down into the anal canal. The gland masses comprise two distinct histological elements, both representing modified sebaceous glands, the hair follicles of which have been lost. Lobules of one type constitute the bulk of the gland and consist of alveoli densely filled with epithelial cells in the course of desquamation. The second type of glandular tissue comprises a smaller number of lobules lying between those of the first type and the muscular capsule. Their alveoli possess an open lumen into which fluid is secreted and cells are shed from the walls concomitantly with secretion to form corpuscles which undergo degenerative and cytolytic changes, some of them encysting first. The ducts of these alveoli are long and branched and pass between the lobules of the first type to open to the exterior together with the ducts of the latter. Active desquamation of epithelial cells takes place in both kinds of alveoli to form a spongy keratinous mass in which is contained the fluid portion of the secretion. Discharge of secretion and protrusion of the papillae seems to be associated with the defense habits of the animal. The fluid is of a pale

brown or creamy color, containing in suspension the cornified remains of epithelial cells and encysted corpuscles. It appears to be odorless and non-acrid.

This paper is confined to the morphology of the glands, but it is hoped that further investigation into the nature and function of the secretion will be possible at a later date. In the meantime it is suggested that the glands may function partly as organs for the excretion of keratin.

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PLATES

PLATE 1

EXPLANATION OF FIGURES

1 View of the posteroventral surface of the animal with the papillae protruded. *1*, anal aperture proper; *2*, left lateral papilla; *3*, right lateral papilla; *4*, median papilla; *5*, genital aperture (male; testes retracted).

2 Anal region with protruding papillae magnified.

3 View of relaxed anus, showing position of openings of the channels formed by the introversion of the papillae. *1*, anal canal; *2*, *3*, *4*, right, median, and left gland apertures, respectively.

4 Dissection to show lower portion of the rectum and inside of skin with the glandular mass. *1*, rectum, cut; *2*, *3*, *4*, right, median, and left anal glands, respectively, forming a tripartite mass; *5*, inner surface of skin; *6*, position of genital aperture (excised).

5 The glands stretched away by their funduses from the rectum.

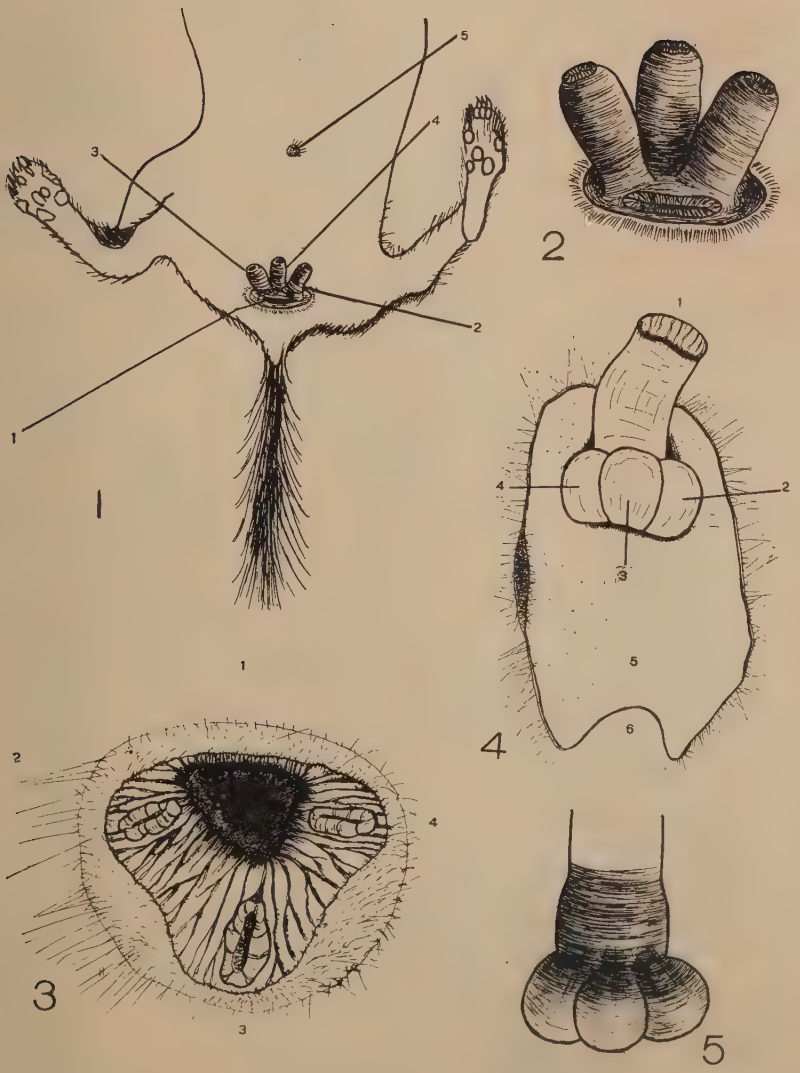
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PLATE 2

EXPLANATION OF FIGURE

6 Longitudinal section through one of the three glands. The introvertible channel of the gland is cut lengthwise, a fold in its wall being sectioned tangentially. The stratum corneum of the channel is frayed out near its base, to become continuous with the desquamated epithelial reticulum of the first-type lobules which are seen clustered in a group of about eight round the base of the channel within the muscular investment. Situated peripherally and outside the first-type elements are to be seen three groups of second-type alveoli. A second-type duct is shown at *5* near to its entry into one of the larger first-type duct mouths. A portion of the lateral retractor ligament is shown at *11*. *1*, debris in mouth of channel; *2*, tangential section of a fold in the wall of channel; *3*, reticulum of desquamated cells; *4* areolar tissue which is prolonged between the lobules; *5*, second-type duct; *6*, first-type duct; *7*, second-type alveoli; *9*, outer muscle sheath; *10*, inner muscle sheath; *11*, retractor ligament; *12*, dermal papillae in rete mucosum of channel wall; *13*, alveolus of first type.

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PLATE 3

EXPLANATION OF FIGURE

7 Transverse section through the whole gland mass. The division into three is seen. The three glands are surrounded by a sheath of striated muscle whose double character is to be seen best at the sides (*6*, *7*). The two types of glandular elements can be distinguished together with their ducts. In the middle gland the channel is seen, the channels of the lateral glands not appearing at the level of the section. *1*, channels; *2*, second-type lobules; *3*, *3*, second-type duct; *4*, stratum corneum of channel; *5*, triradiate connective-tissue junction of epimysia; *6*, inner muscular coat; *7*, outer (common) constrictor coat; *8*, secretion mass in channel—just below, a small portion of the wall is cut tangentially; *9*, *9*, muscular septa; *10*, lobule of first type.

The two types of gland-elements are rendered differently in the drawing. The second-type alveoli are represented by even rings; the first-type are thickened on one side. Compare *2* and *10*. Thus the two types can be distinguished anywhere in the figure.

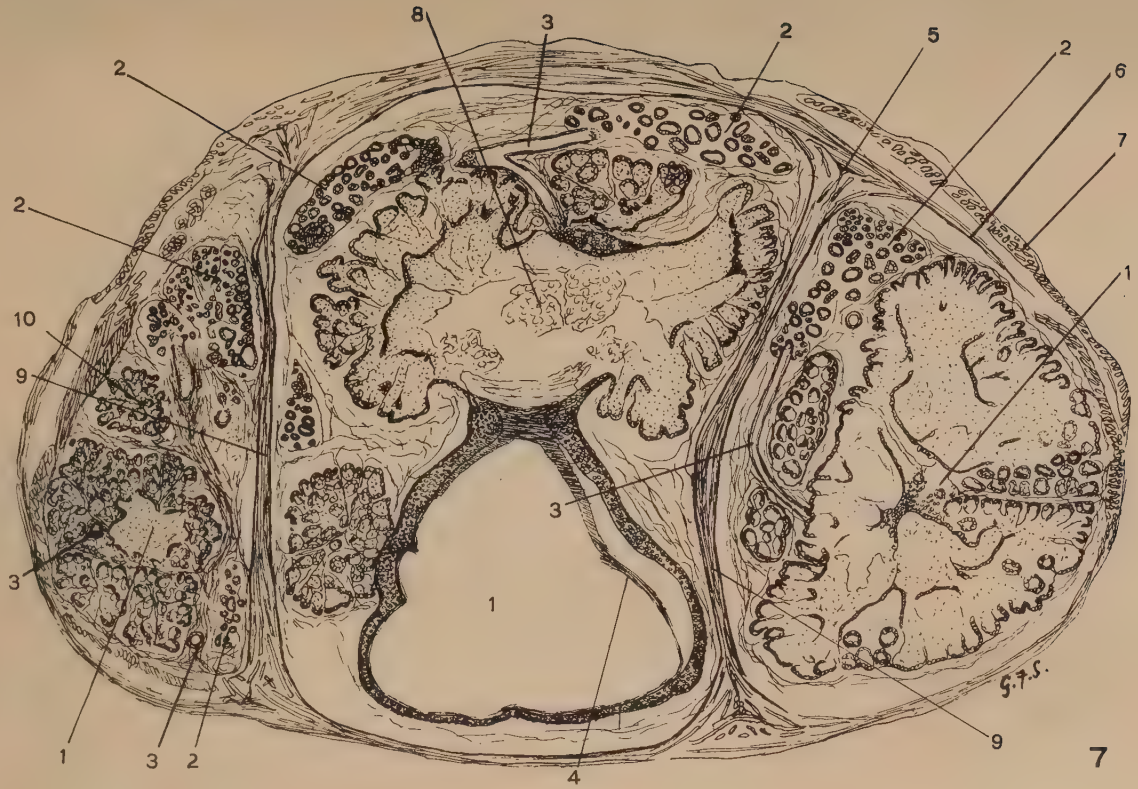
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PLATE 4

EXPLANATION OF FIGURE

8 Section at right angles to the anal canal at the level of the entrance of the three channels (retracted condition). The development of the sphincter ani externus into fasciculi surrounding the channels is shown; to right and left are seen the thick muscle masses at the junctions of sphincter proper and constrictor coat. In the loose connective tissue surrounding the channels are sebaceous glands and hair follicles from the adjacent skin. An extracapsular gland is shown at *10*. *1*, anal canal; *2*, *3*, *4*, channels of the glands; *5*, sphincter ani externus; *6*, thickened portion of muscular sheath at junction with sphincter; *7*, tract of unstriated muscle running in adjacent panniculus adiposus; *8*, dermal papillae in epidermis of channel; *9*, hair follicle; *10*, extra capsular gland; *11*, striated fibers of constrictor coat, which here is very diffuse, bands of it running across the panniculus; *12*, panniculus adiposus; *13*, duct of extracapsular gland; *14*, normal sebaceous gland; *15*, thick detached portion of stratum corneum in channel.

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PLATE 5

EXPLANATION OF FIGURE

9 Longitudinal section through wall of channel near its base, to show the fraying out of the stratum corneum and the pronounced desquamation of the rete mucosum, the shed-off mass becoming highly vacuolated. *1*, region of enlarged epithelial cells of rete mucosum; *2*, outer scaly portion of stratum corneum (the numeral *2* is in the lumen of the channel); *3*, vacuolations in the desquamated mass; *4*, rete mucosum; *5*, stratum corneum; *6*, stratum granulosum.

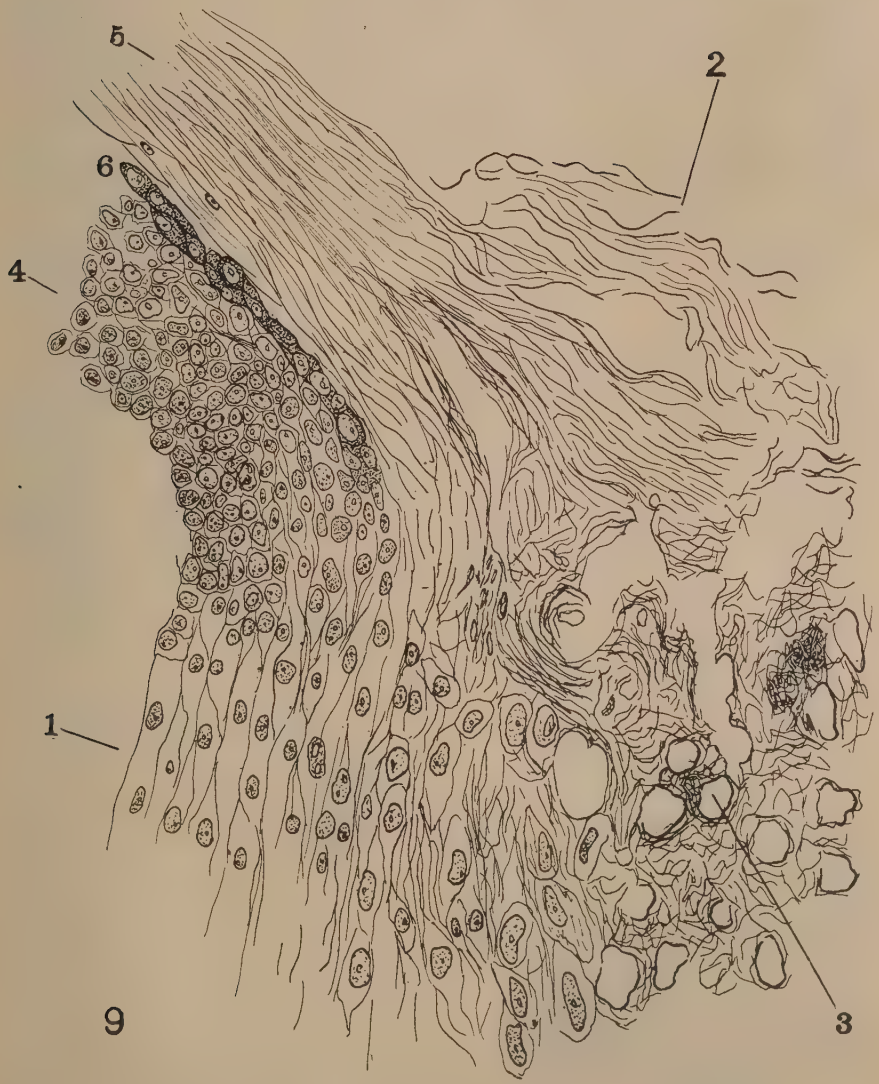
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PLATE 6

EXPLANATION OF FIGURES

10 The retractor muscles and ligament of the median gland near the anal wall. The position of the anal canal is indicated by the sphincter ani internus at *1;* several longitudinal fasciculi run toward the base of the ligament, though its exact junction with them is not shown at this level. The interruption of the constrictor muscle by the ligament is shown and the insertion of the sarcolemmas of the former upon the latter. *1,* sphincter ani internus (edge of); *2,* fasciculi forming retractor muscle of median ligament; *3,* median retractor ligament; *4,* connective-tissue reticulum of the median gland into which the fibers of the ligament merge; *5,* constrictor (striated muscle).

11 View of median retractor ligament, this time on the side of the gland away from the anal canal (it has now circled the fundus of the gland since we saw it in fig. 9). At the top of the photograph is the connective-tissue capsule outside the muscular capsule, containing a few flattened masses of lymphoid tissue (dark). The ligament is seen crossing the constrictor muscle at right angles as before. At the bottom of the photograph is seen the channel of the median gland.

12 Oblique section (low power) through the lower portion of the rectum, to show the lateral retractor ligaments. (The retractor ligament of the median gland appears at a lower level and does not show in this section.) In the top of the photograph is seen the mucous membrane of the rectum thrown into ridges. The circular muscle coat (sphincter internus) is shown at *1,* and immediately outside that the longitudinal coat, at *2.* The longitudinal coat can be seen prolonged down from *2* to be inserted into the group of diverging connective-tissue fibers at *7, 7,* which spread out into the connective-tissue reticulum surrounding the lobules of the two lateral glands. The sphincter ani externus is prolonged into the thickenings of striated muscle in the corners between glands and anal canal. *1,* sphincter ani internus; *2,* longitudinal unstriated coat; *3,* sphincter ani externus; *4,* lumen of rectum; *5,* mucous membrane; *6,* submucous coat of rectum; *7, 7,* lateral retractor ligaments (appearing as strands of connective tissue); *8,* channel of median gland; *9,* junction of common muscular sheath and sphincter ani externus.

13 High-power view of a duct of first type lobule. Its wall consists of a rete mucosum, whose cells, like those of the alveoli, undergo desquamation to join the spongy keratinous reticulum. The vaculations in the reticulum are occupied by fluid together with the corpuscles formed in the second-type gland. One of these corpuscles, encysted or highly keratinized, is shown at *3.* Photograph. *1,* an adjacent first-type duct; *2,* strands of reticulum; *3,* encysted corpuscle which has entered the reticulum of the first-type glands from the second-type glands; *4,* vacuoles; *5,* rete mucosum of duct wall.

14 Transverse section through one of the lateral glands, to show the relationship of first-type and second-type elements. An agglutinated secretion mass is present in the second-type duct, which is thereby distended. The common constrictor muscle is to be seen to the right and above. The individual inner coat is largely incomplete here. The muscular septum separating the median gland shows on the left and its double character is apparent in its upper portion. *1,* first-type glands; *2,* second-type glands; *3,* constrictor sheath; *4,* agglutinated secretion mass in second-type duct; *5,* muscular septum.

15 Section through an outer portion of the first-type gland elements, showing a second-type duct cut transversely. The connective tissue is strongly developed as a sheath around the duct extending upward and to the right between the first-type alveoli. Photograph.

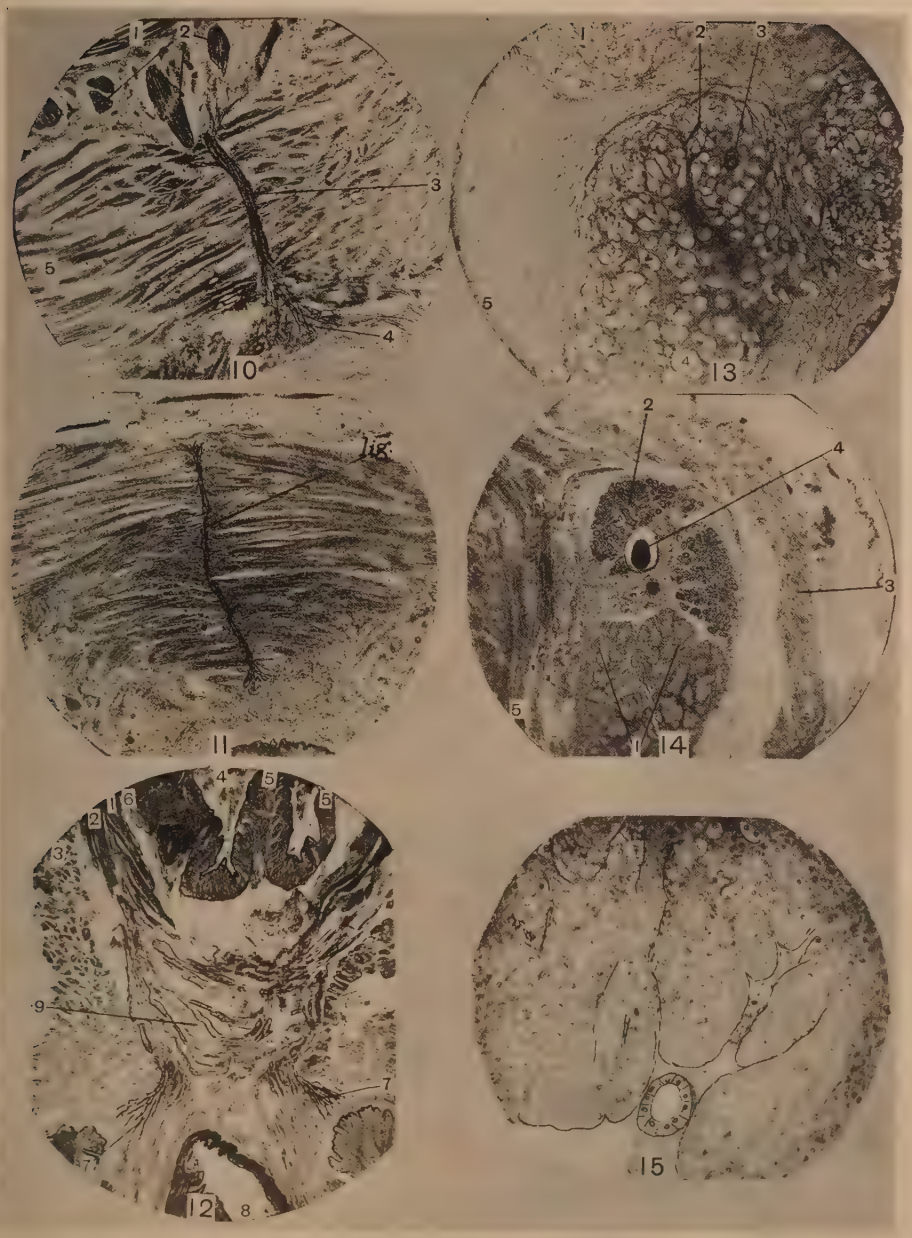
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PLATE 7

EXPLANATION OF FIGURES

16 Section through a portion of second-type gland, to show several alveoli opening into a duct. The wall of the duct is composed of several layers of compact stratified cells which change abruptly in character where they become continuous with the walls of the alveoli. Within the alveoli and the duct are agglutinated masses consisting of the degeneration products of the cells of the alveoli. The changes which take place in the secretory cells prior to shedding are illustrated (see text). Note the large club-shaped processes into which the free ends of the cells are drawn. *1*, secretion mass; *2*, areolar tissue forming framework between the alveoli; *3*, small vein; *4*, basement membrane; *5*, epithelial cell passing out into lumen of alveolus; *6*, nucleus; *7*, an epithelial cell which has been shed into lumen of alveolus, surrounded by secretion mass.

17 Corpuscles derived from the second-type alveoli. The figures illustrate some of the typical changes which occur in the cells during the process of desquamation and disintegration.

In *A* an epithelial cell of the lining of the alveolus is becoming enlarged preparatory to its detachment from the wall. The cytoplasm is becoming clearer and more fluid as indicated by the globular shape. The nucleus is partly filled with fluid, the result of chromatolysis, and the remaining chromatin has broken into two masses.

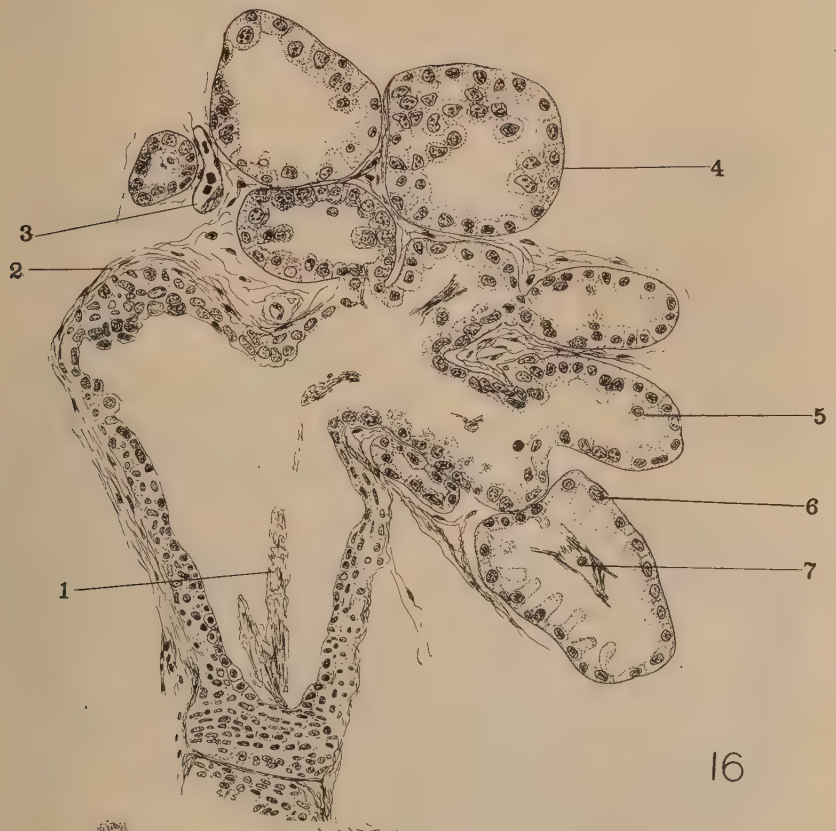
In *B* a detached cell has become almost entirely fluid, and has developed a cyst wall.

C and *E* illustrate a common condition to be observed. The nuclear contents have assumed the form of a curved solid bounded by portions of two spheres, so that the dark mass is roughly convex outward and concave toward the space filled with fluid that constitutes the remainder of the nuclear cavity.

D illustrates the protrusion of the nucleus whole.

F shows the expulsion of the nucleus in fragments.

18 View of a corpuscle from the second-type alveoli which has become embedded in the rete mucosum of a first-type duct in a state of encystment and degenerative division. In all of the division products cytolysis is going on.



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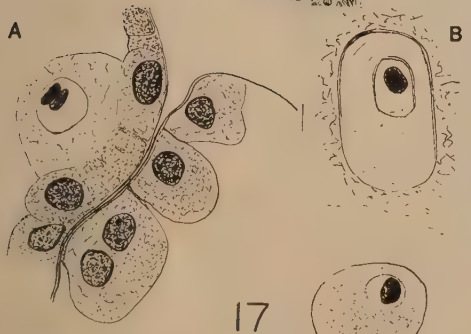

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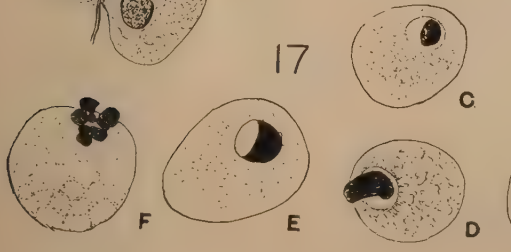

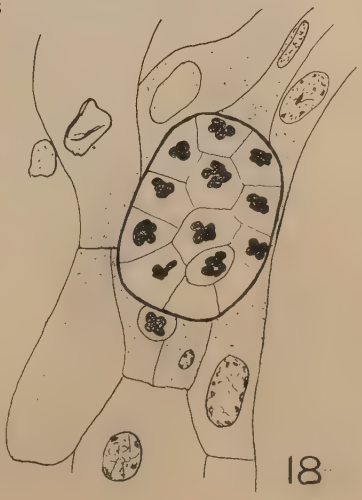

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PLATE 8

EXPLANATION OF FIGURE

19 Diagrammatic representation of the anal glands in the retracted condition. Ventral aspect, the anal canal being hidden from view over a portion of its course by the median gland. The gland on the left is sectioned down its middle, to show the relationship of the constrictor muscles to the rectum. The median gland is cut away on the left. The right gland is not shown except for its channel. *1*, skin; *2*, upper portion of sphincter ani externus; *3*, anal orifice; *4*, outer constrictor coat; *5*, inner constrictor coat; *6*, channel of left gland; *7*, first-type gland elements; *8*, second-type gland elements; *9*, keratinized secretion mass; *10*, second-type ducts; *11*, circular muscles of rectum, continuous with sphincter ani externus; *12*, longitudinal muscular coat of rectum; *13*, inner circular muscle; *14*, lumen of rectum; *15*, anal canal, exposed; *16*, channel of median gland entering anal canal; *19*, channel of right gland; *20*, median gland; *21*, cut area of median gland.

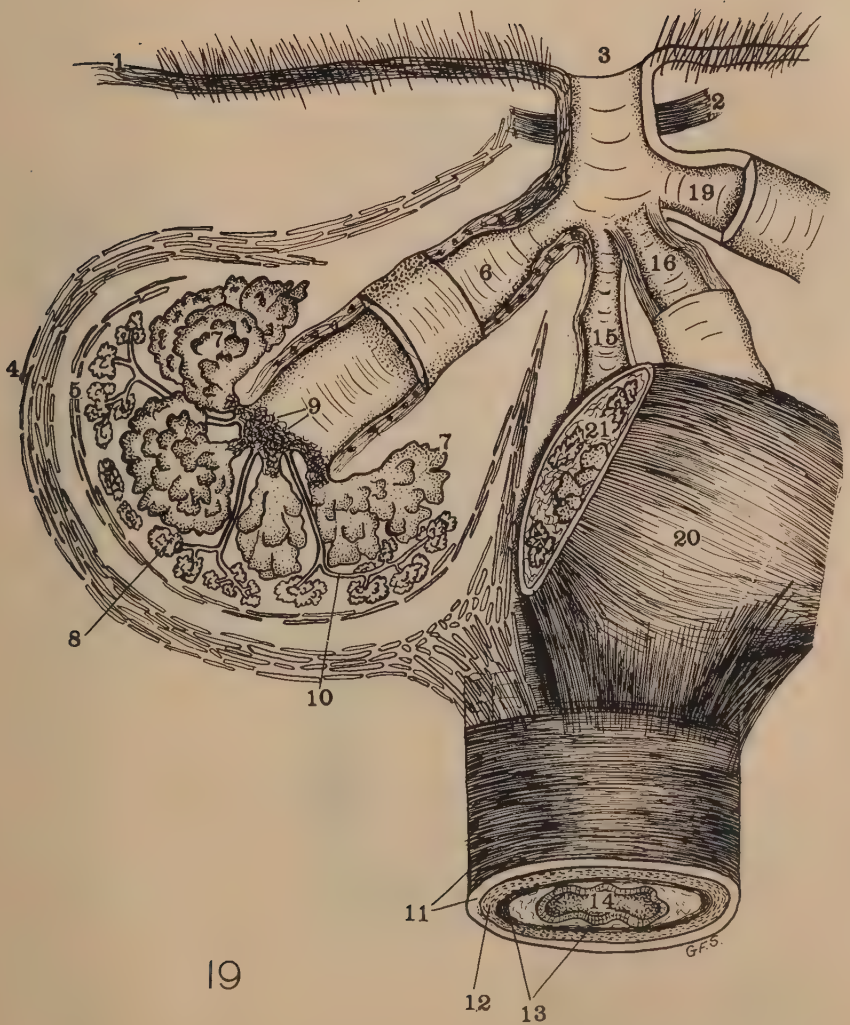

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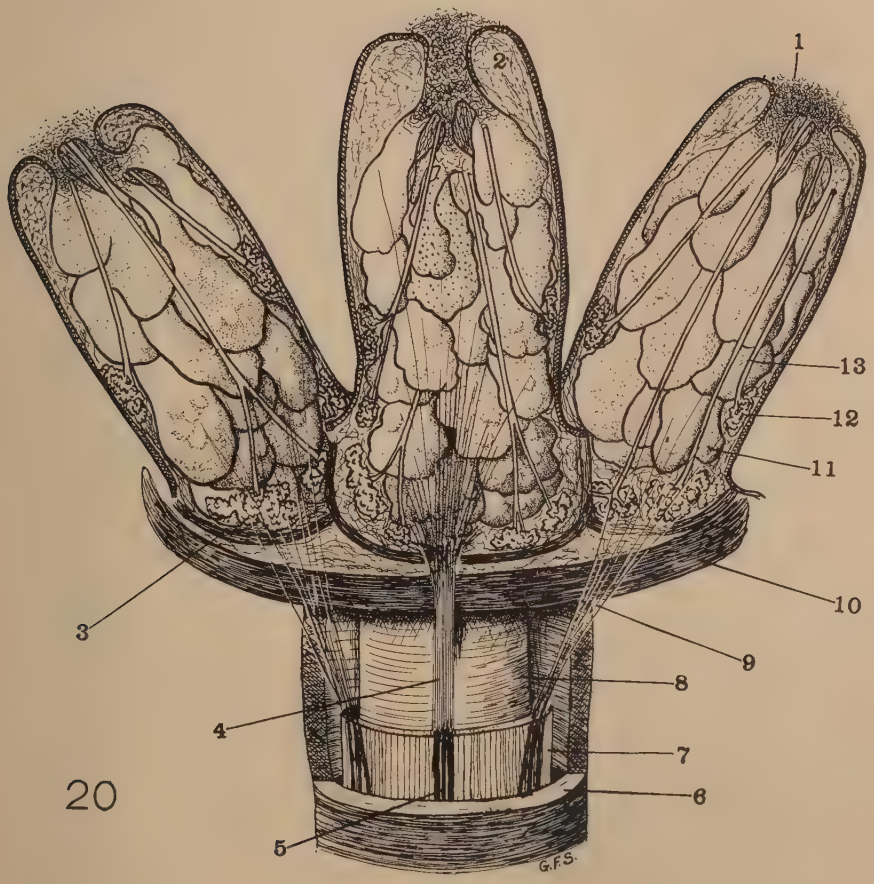
PLATE 9

EXPLANATION OF FIGURE

20 Diagrammatic representation of the anal glands in the everted condition. The constrictor coats are contracted, pushing out the gland masses and causing the channels to turn inside out so that they now appear as papillae filled with the glandular tissue. The two types of glandular elements are shown, the second-type ducts being now very elongated. The figure illustrates the retractor ligaments and the coats of the rectum to display the relationships described in the text. The aspect is ventral; hence the anus is hidden from view by the median gland. *1*, secretion mass being discharged; *2*, loose connective tissue; *3*, inner constrictor coat; *4*, median retractor ligament; *5*, retractor fasciculi; *6*, sphincter ani externus; *7*, longitudinal muscle coat of rectum; *8*, sphincter ani internus; *9*, right lateral retractor ligament; *10*, common constrictor coat; *11*, first-type lobule; *12*, second-type lobule; *13*, second-type duct.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FURTHER OBSERVATIONS UPON THE PLACENTATION OF THE SLOTH (BRADYPUS GRISEUS)[1]

GEORGE B. WISLOCKI
Department of Anatomy, Johns Hopkins University

In volume XVI of the Contributions to Embryology there appeared a study of the placentation of the sloth based upon a specimen of my own and upon seven others described in the literature. Meanwhile, I have secured fourteen other pregnant uteri of sloths. The result of the examination of this material bears out the conclusions of the previous study. However, the relatively large number of specimens in this series and the fact that it was possible to examine them in the fresh condition permits some amplifications of the previous work. This new information upon the placentation of the sloth forms the subject of this paper.

In the course of some six weeks in the Panama Canal Zone, twenty-one adult, female, three-toed sloths of the species Bradypus griseus were purchased from natives who had collected them in the Canal Zone and in the adjacent region of the Republic of Panama. Of these twenty-one animals, fourteen were pregnant and one was accompanied by a newborn individual. The fetuses from the fourteen gravid uteri were all in a late stage of development; the youngest was 37 mm. crown-rump measurement, while the others ranged upward, the larger reaching a crown-rump length of 150 mm. The specimens were obtained between June 15th and July 22nd.

[1] This paper forms one of a series of papers on the anatomy and embryology of the sloth. The material for these studies was obtained and many of the observations were made at the Barro Colorado Island Laboratory, Panama Canal Zone, during the summer of 1925. My sincere thanks are due to Dr. James Zetek, custodian of the laboratory, without whose enthusiastic cooperation this material could not have been obtained nor fully utilized.

From the evidence it seems likely that the three-toed sloth possesses a definite breeding season in the late spring and summer. When the breeding season begins and how long it lasts, no one can say. It is planned, however, to secure female sloths during the months of April and May of next year for the purpose of obtaining a complete developmental series, which will give an approximate idea of the length of gestation.

The uterus of the sloth is characteristically pear-shaped. In order to maintain the form of the uterus and placenta, the uterus was fixed as a whole and opened subsequently. However, a large portion of the amniotic fluid was immediately removed by a syringe and replaced by Bouin's fluid. In the older specimens it was found that 40 cc. of clear, straw-colored amniotic fluid could be removed without the slightest trouble. Meconium is not encountered in the amniotic fluid.

The uterus invariably contains only a single fetus. The older fetuses are invested by a smooth, white, avascular membrane —the epitrichium. This membrane, fitting the fetal body much like a glove, is attached actually to the fetus only about the anus, genital opening, umbilicus, lips, eyelids, nostrils, and the auditory meatus, in which places it blends with the epithelium of these structures. For a short while after its formation, it adheres slightly to the nipples. From the feet the epitrichium extends out over the claws, from which it can be readily stripped away. The membrane, though slightly elastic, can be readily torn. In the younger fetuses it had not formed yet, its appearance being coincident with and the result of the growth of the hairs which, in erupting through the epidermis, lift a cornified layer of epithelium off the body surface in the form of a continuous membrane. In the series examined the epitrichium first appears as a distinct membrane in fetuses measuring about 120 mm.

Some difficulty has been encountered in the selection of a standard measurement for expressing the lengths of sloth embryos. For human embryos the crown-rump length (sitting height), which has always been widely employed, is very

satisfactory. Its use is adapted to all primate forms. It has also been used frequently as the standard for pig and other mammalian embryos. In the case of the sloth, however, its use becomes somewhat arbitrary, because of the extreme flexion of the neck of the fetus. Due to this flexion, the head rests upon the chest, and after fixation it is often impossible to straighten out the vertebral axis of the fetuses without damaging them. This accounts, perhaps, for the fact that the

Notes on series of sloth embryos

NO.	CROWN-RUMP LENGTHS OF THE EMBRYOS	SNOUT TO TIP OF TAIL	DEVELOPMENT OF EPITRICHIUM AND HAIR
	mm.	*mm.*	
1	37	88	No hair. No epitrichium
2	60	130	No hair. No epitrichium
3	76	150	No hair. No epitrichium
4	76	140	No hair. No epitrichium
5	82	160	No hair. No epitrichium
6	85	176	No hair. No epitrichium
7	96	182	No hair. No epitrichium
8	112	195	No hair. Epitrichium just forming
9	122	205	Hair breaking through. Epitrichium formed
10	125	215	Short hair everywhere. Epitrichium well-developed
11	135	215	Short hair everywhere. Epitrichium well-developed
12	140	230	Hair well-developed. Epitrichium well-developed
13[1]	145	245	Hair long and coarse. Epitrichium well-developed
14	150	290	Hair long and coarse. Epitrichium well-developed
15	150	253	Hair long and coarse. Epitrichium well-developed

[1] This specimen was collected in Nicaragua in 1923 and forms the subject of the previous paper on the placentation of the sloth.

few lengths of sloth fetuses which have been given in the literature are stated in terms of some other measurement, most often snout to tip of tail or snout to base of tail, measured along the curvature of the back. For this reason both crown-rump and snout-tip of tail measurements are given in the table of specimens in the present series.

The following brief description of the sloth's placenta is based upon an examination of the present series. It may be pointed out that it agrees substantially with the account given

in the previous paper and much descriptive detail is hence omitted. The placenta of the sloth is composed of numerous lobules of polygonal outline which protrude into the lumen of the uterine cavity. In the youngest stage examined (37 mm. crown-rump) these lobules occupy the whole chorion, so that the uterine cavity is diffusely studded with them. The lobules at this stage are individually from 2 to 4 mm. in diameter. As gestation proceeds, certain portions of the chorion become denuded, so that in the next oldest specimens (60 and 76 mm.) the cervical portion of the chorion has become membranous. This denudation of the chorion results from a resorption of the lobules over certain areas. Meanwhile the lobules which are destined to persist as the functionally active portions of the placenta slowly enlarge, so that at 60 mm. an individual lobule is 4 to 9 mm. in diameter; at 76 mm., 5 to 14 mm. in diameter. In slightly older specimens the lobules disappear in a quite irregular strip up one side of the uterus toward the fundus. The location of this irregular zone of denuded chorion is usually on the ventral surface of the uterus. From an examination of a number of specimens it appears that this resorption occurs opposite the point of attachment of the umbilical cord to the placenta. It is the rule for the umbilical cord to attach to the dorsal wall of the uterus in the midsagittal plane. Its point of attachment in this plane may be high up in the fundus or as low down as the middle of the uterus. Attachment to the lower third of the uterus has never been observed. In three specimens the cord attaches elsewhere: twice ventrally, once laterally. In two of these instances the zone of thinning is located on the wall opposite the point at which the cord attaches. In one instance the thinning and point of attachment are both ventral. As a rule, the umbilical cord attaches to the placenta in a Y-shaped manner, so that one of the two umbilical arteries supplies one-half of the placenta through an arm of the Y. It is not unlikely that the place of thinning opposite the attachment of the cord is due in some way to an unfavorable situation of the vascular supply. This suggestion, how-

ever, is merely tentative for the portions of the chorion which have lost the placental lobules and have become membranous still retain a readily visible supply of fetal blood vessels, so that the placental resorption cannot be attributed to total avascularity.

During the course of gestation more and more of the lower portion of chorion becomes membranous, until toward the close of pregnancy the placenta occupies only about one-third to one-quarter of the entire chorion. But, although there are fewer lobules than at a period earlier in gestation, yet these lobules have grown steadily in circumference, and to some extent in depth, until their total surface area is greater than at any time previously. These changes are concurrent with the gradual growth of the uterus and the enlargement of the uterine cavity. The placenta is situated in the fundic half of the uterus and occupies the dorsal and lateral walls of the chamber. As has been said, an irregular seam of membranous chorion occupies the ventral wall of the fundus when the umbilical cord, as is the rule, attaches to the dorsal wall. Meanwhile, the remaining functional lobules have continued to increase in size until they reach an individual diameter of from 1½ to 2½ cm. Toward the close of gestation the placenta assumes then the form of a lobulated mass in the fundic portion of the uterus. Its outline at this time is variable. It remains in some instances a single mass with a deep, irregular cleft separating it into right and left halves. In other instances a second longitudinal seam of membranous chorion arises along the dorsal surface of the placenta, so that the placental mass becomes converted into two separate halves, supplied each by its own arm of the Y-shaped division of the umbilical cord. In my own material, however, I have not observed the formation of two widely separated, symmetrical, kidney-shaped halves with smooth contours, occupying opposite faces of the fundus, as described and pictured by Klinkowström (Zool. Jahrb., vol. 8, pp. 481–519) in his mature specimen. In my experience, although two separate lobes often arise, they never become separated by

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more than a narrow, irregular strip of chorion, and, above all, their contours are so irregular that it takes often a careful examination to establish their independence.

The examination of the fresh placentae adds two additional observations to the previous account. In the fresh, a distinction in color can be made out, on looking at the fetal surface of the placenta, between viable lobules and those undergoing resorption. The functional lobules appear reddish purple, whereas the degenerating lobules are pale, exhibiting a cream or buff color. The latter are most numerous along the borders of the receding placenta.

The other observation concerns the amniotic covering of the fresh placenta. On carefully examining it, numerous small elevations can be seen scattered over its surface. These have the appearance of slightly transparent, pearly or waxy droplets. They occur about equally abundantly over membranous chorion and placenta, showing a tendency to segregation along the blood vessels. The elevations attain a diameter of about 1 mm. in the mature placentae, while they are considerably smaller in the younger specimens, being just on the threshold of visibility. After fixation they become much less readily visible, no longer conspicuous by their transparency, and look often like insignificant puckerings of the amnion due to fixation. Moreover, on examining our series of fixed specimens, it is observed that in placentae of the same stage of maturity, there is a great variability in the number which can be discovered, some specimens being studded with them, others exhibiting hardly any.

Microscopic sections through areas in which the elevations are abundant reveal their histological nature, which differs slightly from the usual description of 'amniotic villi.' The amniotic mesoderm forms in places small whorls of connective tissue which cause low elevations to appear on the surface of the amnion. The amniotic epithelium, except over these elevations, consists of a single layer of low, elongated cells. Over the elevations the epithelium is characteristically composed of cuboidal epithelial cells with their bases irregu-

larly disposed upon the underlying stroma. Their cytoplasm is unusually deeply stained with eosin and shows little differentiation except for, now and then, a somewhat foamy appearance toward the surface paries. The stroma of the whorl is distinguished from the ordinary amniotic stroma by an unusual number of conspicuous stellate cells disposed near the surface of the elevation beneath the amniotic epithelium.

PROCEEDINGS OF THE TWENTY-THIRD ANNUAL MEETING OF THE AMERICAN SOCIETY OF ZOÖLOGISTS

NEW HAVEN, CONNECTICUT, DECEMBER 28, 29, 30, 1925

The 1925 program of the American Society of Zoölogists was held at Yale University, New Haven, Connecticut, December 28th, 29th, and 30th. The President and Secretary of the Society and one member of the Executive Committee were present, the Vice-president and Treasurer being absent because of illness. The Genetics Sections were represented by L. C. Dunn.

The day sessions were held in the main lecture amphitheater of the Osborn Zoölogical Laboratory and were well attended, the average attendance being between sixty-five and seventy-five. An outstanding feature of these sessions was the large amount of discussion of papers—a feature which has, unfortunately, usually been conspicuous by its absence.

The Osborn Zoölogical Laboratory afforded ideal facilities for the meeting and the many details of local management and hospitality, upon which so much of the success of meetings depends, had been admirably worked out by the Local Committee. The ladies of the Department of Zoölogy at Yale contributed greatly to the enjoyment of the meetings by their hospitable teas of Monday and Wednesday afternoons.

PROGRAM

In the following summary papers are designated by their program numbers (compare December number of this journal).

MONDAY, DECEMBER 28TH

10.00–12.45 President Stockard presiding.

Embryology, Cytology, Protozoology, and *Parasitology.* Papers 1 to 45, inclusive.

In addition to the papers designated 'by title' in the program, papers 3, 15, 16, 17, 18, 26, 27, 29, 30, and 39 were read by title.

2.00–4.30 President Stockard presiding.

Comparative Anatomy, General Evolution, Ecology, Miscellaneous and *General and Comparative Physiology.* Papers 46 to 71, inclusive.

By consent of the Society, the afternoon session was opened by a paper by William Patten:

New Ostracoderms from Spitzbergen

WILLIAM PATTEN
Dartmouth College

Explorers have recently found well-preserved Ostracoderms in Spitzbergen. Last summer, aided by a grant of $250 from the Scandinavian American Foundation, I went to Spitzbergen to determine the feasibility of further exploration for fossil fishes in that remote and rather difficult region.

At Advent Bay a small hunting boat was chartered, in which, under favorable ice conditions, I went to northwest Spitzbergen, going in all about 400 miles. Some Ostracoderms were obtained, deposits located, and the probability of obtaining more material was assured, provided requisite assistance could be obtained.

Many specimens collected by Major Isaacsen are now in the State Museum, Stockholm, under investigation by Professor Stensiö. On my return from Spitzbergen, Professor Stensiö, with rare generosity, placed his beautiful preparations at my disposal. This scientific idealism, so common in theory and so rare in practice, is all the more noteworthy since the fossils are veritable miracles of anatomical preservation in an extinct, little-known class of animals where every detail is of utmost importance.

In his specimens blood vessels, cranial nerves, semicircular canals, and oral gut lobes are shown with a distinctness more suggestive of anatomical preparations than fossils.

These new facts, so unexpectedly revealed, are in striking agreement with the author's previously expressed views as to the derivation of vertebrates from a pre-Cambrian Arachnoid stock, for these new facts, with the old, conclusively show that the basic structural and functional plan of such arachnids as Limulus, scorpions, and Eurypterids is practically identical with that of primitive vertebrates.

In addition to the papers designated 'by title' in the program, papers 46, 58, 63, 64, and 65 were read by title. By consent of the Society paper 78 was read at this session.

7.00–10.00 P.M. Annual Zoölogists' Dinner. University Dining Hall.

Retiring President Ross G. Harrison gave an address on Embryology, after which President Stockard called on President C. C. Little, of the University of Michigan, and Professor G. H. Parker, of Harvard University, for brief remarks. Attendance, 135.

TUESDAY, DECEMBER 29th

9.00–11.30 President Stockard presiding. Papers 72 to 95, inclusive.

In addition to the papers designated 'by title' in the program, papers 74 and 75 were read by title.

By consent of the Society, the following two papers were introduced by title:

Orientation to the Electric Current and to Light in Amoeba

R. H. LUCE
Zoölogical Laboratory, Johns Hopkins University

When an Amoeba proteus, not attached to the substratum, is subjected to an electric current, it is carried passively to the anode. When attached to the substratum, it orients and moves toward the cathode. The character of the orientation depends upon the strength of the current or the potential drop. Orientation is slow and uncertain with weak currents, and becomes more rapid as the current increases, until direct reversal of flow takes place. Still stronger currents cause immediate cessation of movement and ultimate cytolysis. Orientation is brought about by the formation of pseudopods on the cathode side, the effect of the current being to cause tendencies toward solation on that side.

Orientation to light in Amoeba is brought about by a greater gelation and consequent inhibition of pseudopod formation on the more highly illuminated side. The process of orientation in light is dependent upon the intensity of the stimulating agent, just as it is in an electric current, except that direct reversal in light is preceded by total cessation of movement, which apparently is due to excessive gelation.

Orientation is outwardly similar, but in the electric current pseudopods are formed on the cathode side, owing to solation on that side, while in light, pseudopod formation is inhibited on the illuminated side, owing to gelation on that side.

Effect of Salts on the Direction of the Stroke of the Cilia in Paramecia adapted to Pure Water

S. O. MAST AND J. E. NADLER

Paramecia, adapted to pure water, were put into solutions of various salts in various concentrations and combinations. The following was observed:

1. Monovalent salts induce reversion in the direction of the stroke of the cilia, bivalent and trivalent salts do not.

2. The duration of reversed action varies with the kind of salt and with the concentration. In KCl, as the concentration decreases, the duration of this action increases from zero at M/10 to a maximum of about twenty-five seconds at M/750, then decreases to zero at M/1000. In NaCl it increases from zero at M to a maximum of about nine seconds at M/500, then decreases to zero at M/2200. In NH_4Cl it increases from zero to M/50 to a maximum of about six seconds at M/1000, then decreases to zero at M/2200. In LiCl it increases very rapidly from zero at M/5 to a maximum of about thirty-three seconds at M/10, then decreases slowly to zero at M/2000.

3. Bivalent and trivalent salts neutralize the effect of monovalent salts. The relative amount required varies with the kind of salt used and with the concentration. To neutralize 1 cc. of LiCl M/500 it requires in M/1000 1.055 cc. $CaCl_2$, 20.955 cc. $MgCl_2$, or 0.0702 cc. $FeCl_3$. To neutralize 1 cc. of KCl M/500 it requires 0.42 cc. $CaCl_2$, 3.56 cc. $MgCl_2$, or 0.1062 cc. $FeCl_3$. To neutralize 1 cc. KCl M/10, M/100, and M/1000 requires 3.67, 0.863, and 0.1225 cc. $CaCl_2$ M/1000, respectively.

4. The results seem to indicate that ciliary reversion is associated with differential adsorption and consequent changes in electric potential.

2.30 Dedication of the New Peabody Museum.

President Angell, of Yale University, presided. Addresses were given by Prof. Charles Schuchert, of Yale University, and Dr. Henry Fairfield Osborn, of the American Museum of Natural History. Following the program, the building was open for inspection.

8.30–11.00 P.M. The Biological Smoker was given at Byers Hall by local members of the American Society of Naturalists and the American Society of Zoölogists in cooperation with Yale University.

WEDNESDAY, DECEMBER 30TH

9.10–11.30 President Stockard presiding.

Symposium on the cancer problem.

Genetic studies on the nature of cancer. L. C. Strong, Bussey Institute, Harvard University.

Discussion of certain etiological factors in the causation and transmission of malignant tumors. James B. Murphy, Rockefeller Institute.

The rôle of functional activity in the production of mammmary carcinoma. Halsey J. Bagg, General Memorial Hospital and Cornell Medical College.

Dr. Erwin F. Smith, of the Bureau of Plant Industry, was unable to be present, and his paper on "The medical, or tumor, aspects of the crowngall problem" was not presented.

The discussion was opened by James Ewing, Cornell University, and was followed by a general discussion. Attendance, 125.

TUESDAY, DECEMBER 29TH

11.30–12.30 Business meeting, President Stockard presiding.

Reports of officers

Through the Secretary, S. I. Kornhauser, representative of the Society on the Executive Committee of the Commission for the Standardization of Biological Stains, presented the following report for the year 1925:

At the present time all of the important stains generally used in laboratories are standardized and are on the market bearing the label of the Commission. This list includes various blood stains in which the dry powders have been passed by the Commission.

The rapid progress for the past year has been possible through the generosity of the Chemical Foundation, which has paid the salary of a full-time technician and an assistant for the Chairman of the Committee and has also provided funds for stains to be tested in other laboratories. There has also been some revenue from the sale of certification labels to the manufacturers and jobbers.

The Commission has published a book on "Biological Stains" giving information concerning the constitution and uses of almost all dyes used in biological laboratories. More than 500 copies of this book were ordered before it appeared on the market. Many requests came from abroad. The Commission is planning to publish a quarterly called "Stain Technology," which journal will deal with biological dyes and their uses. The first number will appear early in 1926. I might also add that the Chemical Foundation will back this journal in a financial way.

Your representative attended two meetings held in New York in May and November. He has assisted in the preparation and correlation of the manuscript of the book and has undertaken the standardization of the following dyes during the past year: Janus green, neutral red, carmine, Congo red, Nile blue sulphate, and tetrachrome blood stain. He is very anxious to have the members of the Society communicate with him concerning their needs in biological dyes, and is especially anxious to know if any of the certified dyes have failed to give proper results.

S. I. KORNHAUSER.

The Society accepted the report of Doctor Kornhauser and ordered him continued in his present capacity.

J. A Detlefsen presented the following report from C. E. McClung, whose present term of office as managing editor of the Journal of Morphology and Physiology expires in 1926:

Data regarding the Journal of Morphology and Physiology for the period 1921–25

Number of manuscripts from Doctor Kingsley		19
Number of manuscripts submitted		155
Number declined	33	
Number published	104	
Number pending	37	
	174	174

Items regarding policy. Name of publication changed to Journal of Morphology and Physiology.

Individual papers made available for subscription.

Financial support by Society changed from a definite fixed amount to that resulting from individual subscriptions.

Majority of subscriptions now by individual papers instead of by journal.

Impending changes. More rapid publication by reason of more printing machinery.

Better illustrations, possibly by direct photographic methods.

C. E. MCCLUNG.

The Secretary reported that the membership of the Society consisted of one honorary fellow, six life members, 388 active members, and 25 associate members. (The election of new members later in the meeting brought this up to 416 active members and 33 associate members, making the total membership for the Society 456.) There were no resignations during the year.

F. W. Carpenter and B. H. Ransom died during the year.

The report of the Secretary was accepted and ordered filed.

Owing to illness at the last moment, the Treasurer was unable to be present at the meetings and was unable to present a report. The President appointed an auditing Committee, consisting of E. L. Rice, chairman, and W. W. Swingle, to examine the report as soon as it should be presented.

REPORT OF NECROLOGY COMMITTEE

The Necrology Committee submitted minutes on the deaths of two members during the past year:

Minute on the death of Frederick Walton Carpenter

Frederick Walton Carpenter, of Colonial Quaker ancestry, was born at Millbrook, New York, on May 12, 1876, and died at Hartford, Connecticut, on March 1, 1925. In the course of his early education he attended the schools of his native town. In 1899 he received his bachelor's degree from New York University. He went to Harvard University for graduate work in biology and attained the doctorate of philosophy there in 1904. His biological studies were then continued in foreign universities—Berlin, Munich, and in the neurological institute at Frankfurt-am-Main. Upon his return from Europe, he became a member of the staff of the Department of Zoölogy at the University of Illinois. In 1913 he was appointed to the J. P. Morgan Professorship of Biology at Trinity College and held that position to the time of his death.

He was a member not only of the American Society of Zoölogists, but of the American Association for the Advancement of Science, the Association of American Anatomists, and of the Phi Beta Kappa, Sigma Xi, and Zeta Psi fraternities. During the summer season of 1909 he was Acting Director of the Bermuda Biological Station for Research. In 1918 he served with the American Red Cross as sanitary director at Camp Devens, holding the rank of major. He did important work among the soldiers during the influenza epidemic of that year.

In his academic capacity, Doctor Carpenter achieved extraordinary success as an efficient and inspiring teacher. Due to his insight, breadth of view, and lofty ideals for the medical profession, the premedical course at Trinity College became, during his professorship, one of the best in the country. His researches in his chosen field, the morphology and development of the nervous system, have been important and extensive. He rendered valuable services as a member of the Commission on the Standardization of Biological Stains. His latest biological undertaking consisted in a study of the ecological conditions attending the decrease in number of the caribou of Nova Scotia and Newfoundland.

Doctor Carpenter's life, although prematurely ended, stands as a model of the life of an academic man of science. In every one of its aspects it was adequate, successful, and creatively active. To his students he was inspiring, helpful, and an example of manhood of the finest type. By his colleagues he was held in highest respect and esteem. His contributions to neurology constitute an enduring monument to his scientific ability. His fairness, his tolerance and generosity, his fine inherent courtesy, and his quiet, genial humor endeared him to all who had the privilege of association with him.

HERBERT W. RAND,
L. J. COLE.

Minute on the death of Brayton H. Ransom

After a quarter century of productive research, Dr. Brayton H. Ransom, Chief of the Zoölogical Division of the Bureau of Animal Industry, U. S. Department of Agriculture, died September 17, 1925, at the age of forty-six years. In his death the American Society of Zoölogists has lost an outstanding member. He had made many important contributions in pure and applied zoölogy and had an unusually happy faculty in following up his purely scientific investigations with practical applications of his results. Possibly his most striking work of this sort was his detailed and painstaking study of the life-history of the swine roundworm, Ascaris lumbricoides, and the subsequent application of the knowledge thus obtained to the development of a swine sanitation system, which has already paid the swine raisers of the Middle West large profits by eliminating the many losses due to worms and other causes associated with the raising of young pigs in filthy surroundings. In addition to his scientific qualifications, Doctor Ransom was a capable and considerate executive and a very delightful friend. This Society greatly regrets the early death of a scientist of so great ability and of a man of such sound and pleasing personal characteristics.

SEWALL WRIGHT,
MAURICE C. HALL.

The minutes were adopted by rising vote and were ordered spread upon the records, and copies of the minutes were ordered sent to the families of the deceased.

ELECTION OF OFFICERS

The Nominating Committee (Art. III, Sec. 6), composed of H. S. Jennings, Harold Heath, and Fernandus Payne, submitted the following report:

President, one year, S. O. MAST, Johns Hopkins.
Vice-President, one year, W. C. ALLEE, Chicago.
Executive Committee, five years, C. R. STOCKARD, Cornell Medical School.
Journal of Morphology and Physiology, Managing Editor, five years, C. E. MCCLUNG, Pennsylvania.
Journal of Morphology and Physiology, Associate Editors, three years (three to be elected), M. H. JACOBS, Pennsylvania; L. J. COLE, Washington, D. C.; J. H. GEROULD, Dartmouth.
Representative in the Division of Biology and Agriculture of the National Research Council, three years (one to be elected), E. G. CONKLIN, Princeton.
Representative on the Council of the A.A.A.S., one year (two to be elected), MAYNARD M. METCALF, Johns Hopkins; H. V. NEAL, Tufts.

Nominations from the floor were called for, but not being presented, the Secretary was ordered to cast a ballot for the above list of nominees.

The President appointed the following nominating committee for 1926: William Patten, chairman; W. H. Longley, and A. F. Shull.

ELECTION OF NEW MEMBERS

The Executive Committee recommended, and the Society elected, twenty-eight active and eight associate members, making a total of thirty-six new members. The names of these newly elected members will be found following the old membership list at the end of these Proceedings.

MISCELLANEOUS BUSINESS

Ross G. Harrison, Society representative on the Council of the Union of American Biological Societies, presented a brief account of the present status of Biological Abstracts.

An invitation to members of the Society to participate in the program of the Sixth International Congress of Phliosophy, to be held at Harvard University, September 13 to 17, 1926, was presented on behalf of the Organizing Committee of the American Philosophical Association. At the general session, under Division A of the Congress, Emergent Evolution will be discussed.

The Society having been invited through its President to appoint a representative to attend the Third Pan-Pacific Science Congress, to be held in Tokyo, October 27 to November 9, 1926, the President appointed G. H. Parker, of Harvard University.

It was suggested that hereafter the list of members be printed with the program as in previous years and, further, that separate programs be printed for the advance information of members and for distribution to the public wishing to attend sessions.

The thanks of the Society were voted to the local committee, consisting of G. A. Baitsell, W. W. Swingle, and J. W. Buchanan, for their efficiency in carrying out the local arrangements for the meetings.

D. E. Minnich, *Secretary.*

AMERICAN SOCIETY OF ZOÖLOGISTS

OFFICERS AND LIST OF MEMBERS

Officers for 1926

President.....S. O. Mast
Vice-President.....W. C. Allee
Secretary.....D. E. Minnich
Treasurer.....L. B. Arey

Executive Committee

Charles A. Kofoid.....1926
H. H. Wilder.....1927
M. F. Guyer.....1928
R. G. Harrison.....1929
C. R. Stockard.....1930

Officers of Genetics Section

Chairman.....S. G. Wright
Secretary-Treasurer.....L. C. Dunn
Society Representative.....R. A. Emerson
Representative on Editorial Board of Journal of Heredity.....M. Demerec

Representatives of the Society in the Division of Biology and Agriculture of the National Research Council

J. T. Patterson.....1927
L. L. Woodruff.....1928
E. G. Conklin.....1929

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MINUTES OF THE JOINT GENETICS SECTIONS MEETING AT KANSAS CITY, DECEMBER 29 AND 30, 1925

Two meetings were held this year. A genetics program was given at New Haven, Connecticut, in conjunction with the American Society of Naturalists, while the official meeting was held at Kansas City, Missouri, where sessions for the reading of papers were arranged for Tuesday morning and Wednesday afternoon. Prof. H. H. Bartlett, chairman presided.

Twenty-nine papers were given at New Haven, of which seven were on botanical subjects and twenty-two zoölogical. At Kansas City, twenty papers were presented, of which ten were zoölogical and ten botanical in subject-matter.

The following officers were nominated and elected for 1926:

Chairman, S. G. Wright.
Society Representative, R. A. Emerson.
Secretary-Treasurer, L. C. Dunn.
Representative on Editorial Board of the Journal of Heredity, M. Demerec.

It was moved and carried that the Secretary-Treasurer be elected for a term of three years.

The average attendance at the Kansas City meeting was about 150.

The enrollment in the two sections is 121 members of the Zoölogical Society and 84 members of the Botanical Society.

MEMBERS OF THE AMERICAN SOCIETY OF ZOÖLOGISTS ENROLLED IN THE GENETICS SECTION

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Baitsell, G. A.
Ball, G. H.
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Bartsch, P.
Behre, E. H.
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Bruner, H. L.
Carothers, E. E.
Carroll, M.
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Chester, W. M.
Cole, L. J.
Collett,, M. E.
Colton,, H. S.
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Curtis, W. C.
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